METAVERSE: ADVANCEMENTS, APPLICATIONS, AND EDUCATION

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ABSTRACT

The Metaverse, a concept first introduced in 1992, has evolved significantly to encompass augmented reality (AR), virtual reality (VR), and extended reality (XR). This paper defines the Metaverse, explores digital twins, and examines the educational applications of the Metaverse. It also highlights how countries and companies have embraced this concept and delve into future advancements in blockchain, artificial intelligence (AI), and cloud computing. The Metaverse's potential across various fields is underscored, particularly its role in education, interactive learning, and immersive experiences. This study aims to provide a comprehensive understanding of the Metaverse and its far-reaching implications.

KEYWORDS: Metaverse, Augmented Reality (AR), Virtual Reality (VR), Extended Reality (XR), Multiverse, Digital Twins, Education, Blockchain, Artificial Intelligence (AI), Cloud Computing, Future Advancements, Global Impact, Technology Integration, Interactive Learning, Immersive Experiences

INTRODUCTION

The term "Metaverse," first used in 1992, has evolved significantly. This paper defines the Metaverse and connects it to AR, VR, XR, and the Multiverse. It also explores what digital twins are and delves into the educational applications of the Metaverse. The paper also explores how countries and companies have embraced this concept. Additionally, the paper examines future advancements in blockchain, AI, and cloud computing, thereby highlighting the Metaverse's potential across various fields.

Chapter 1: Defining the Metaverse: Navigating the Ambiguity

"The investments in the Metaverse would reduce operating income by over $10 billion in 2021"
– David Wehner (Chief Financial Officer - Meta)

"A Microsoft-led enterprise Metaverse"
– Satya Nadella (CEO - Microsoft)

"The economy in the Metaverse ... [will] be larger than the economy in the physical world"
– Jensen Huang (CEO & Founder - Nvidia).

"This Metaverse will be far more pervasive and powerful than anything else. If one company gains control of this, they will become more powerful than any government and be a God on Earth."
– Tim Sweeney (CEO - Epic Games) [1]

Each of these remarks regarding the Metaverse holds significance. Before delving into a detailed explanation of what the Metaverse comprises, we must first answer the following question: What exactly is the Metaverse?

1. Definition

Metaverse in easy words

The word 'metaverse' was first coined in a piece of speculative fiction named Snow Crash, written by Neal Stephenson in 1992; it resembles a big, connected "post-reality universe" [1]. In the Metaverse, technology blends with real life. Here, one can interact with friends, trade, create, and learn new things - all while feeling like they are there, even if they are not. The Metaverse is poised to become a digital platform that enables interaction, immersion, and engagement within an environment parallel to the physical world. It is the next step in Augmented Reality (AR) and Virtual Reality (VR) and involves multisensory interactions. It is more than a buzzword now; it is a concept with great potential to revolutionize the future. [6]

The Shifting Landscape

The metaverse is a shift in technology interaction, including VR and AR but not limited to them. It is a digital economy where users can trade virtual goods and assets, but interoperability remains complex. Familiar experiences like World of Warcraft and Fortnite share traits with the metaverse.

The Metaverse as an Ecosystem

Like Google's role in the internet, Meta and Microsoft develop metaverse-related tech but don't define it entirely. Many companies, from Nvidia to Roblox, contribute to the infrastructure for lifelike virtual worlds. For instance, Epic Games' Unreal Engine 5 expands into film and beyond; these developments signify tangible progress in building digital realms.

The Multiverse of Metaverses

The multiverse is the next stage, and some individual games or platforms, like VR Concert apps, fall into this category. Some

describe this as a "multiverse of metaverses" or "hybrid-verse". This definition remains fluid, evolving at a breakneck pace. We'll learn more about the Multiverse in the next section. [3]

1.2. AR, VR, Metaverse, and the Multiverse
To better understand how these immersive technologies interact with the environment, we refer to Milgram and Kishino's one-dimensional reality-virtuality continuum [3]. This is like a line with two divided ends. On the left side is a natural and physical (real-world) environment, whereas on the right side is a fully artificial, virtual environment. Hence, AR is near the left end of the spectrum, while VR occupies the right extremum. MR is a superset of both. [6]

The Multiverse aims to integrate the digital and real worlds. While the Metaverse primarily emphasizes VR and AR experiences, the Multiverse focuses on XR. It offers eight different advanced XR experience realms. "The Metaverse will be the precursor of the so-called Multiverse." [23]

People can hang out and be together using XR tech like VR and AR in the Metaverse. Making this virtual world feel real is tricky because current gadgets, like VR headsets, have much scope for improvement when making us feel like we're touching things. Scientists are working on new materials and gadgets to make VR feel more real, but there are still challenges and things to think about, like how it might affect our privacy and mental health. [24]
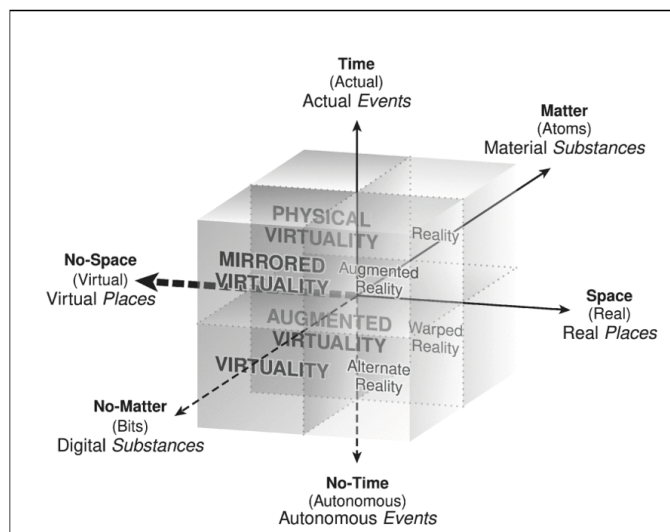
Figure 1: The Multiverse as an architecture of advanced XR experiences: Three dimensions, six variables, and eight realms [12]

1.3. Current use of the Metaverse
The Metaverse is slowly becoming a part of our everyday reality; from social gatherings to legal proceedings, weddings to sports, the Metaverse is revolutionizing various parts of our lives. Some of the progress already made includes:

1. **Social Connectedness**
   - Implementation: There is a high likelihood that virtual reality can connect people regardless of their geographical location. People can go to events and concerts as well as socialize with friends and family.
   - Implementation Example: Harvard Business School conducted an alumni reunion in the metaverse and brought all the alumni from different countries together without having to take a flight. [9]

2. **Legal Proceedings**
   - Implementation: Metaverse technology is implemented in courts for holding court hearings, meaning that participants are represented via virtual avatars.
   - Example Implementation: Colombian courts recently used Meta's Horizon Worlds for a legal hearing where participants were represented through virtual avatars. [9]

3. **Weddings**
   - Implementation: Marriage ceremonies are virtually conducted; everything is done, and managed by the conjunction of virtual avatars as well as digital twins.
   - Example Implementation: The entire wedding of Candice and Ryan Hurley took place in the Decentraland Metaverse. Avatars of the bride and groom, along with guests, attended the virtual ceremony. [9]

4. **Sports**
   - Implementation: Sports teams are developing virtual stadiums and interactive experiences that fans can use to meet players and be part of the action.
   - Implementation Examples: The Islamabad United Cricket Team built a virtual stadium on the Decentraland and challenged their fans to experiences and games. [9]

5. **Travel and Tourism**
   - Implementation: The travel industry has constructed travel-boarding experiences and virtual reality travel and tour options after unlocking the potential of metaverse technologies.
   - Example Implementation: From Qatar Airways Lounges to Bangalore International Airport, many have already set up shop in the metaverse to give travelers the most immersive experiences possible. [9]

6. **Banking**
   - Implementation: There are virtual branches of banks where transactions, consultations, and services can take place round the clock with almost zero carbon footprint.
   - Example Implementation: Through a metaverse branch in Decentraland, Commercial Bank International extended traditional and crypto finance services to all. [9]

7. **Law Enforcement**
   - Implementation: Even the police agencies are using the metaverse for the training and education systems. It forms their virtual headquarters.
   - Example Implementation: INTERPOL got its

headquarters in the metaverse for training and educating its staff globally. [9]

8. **World Economic Forum**
   • Implementation: Organizations get virtual spaces to conduct collaborative activities, network, and support knowledge sharing throughout the year.
   • Use case instance: The World Economic Forum, in partnership with Microsoft and Accenture, launched the metaverse Global Collaboration Village to help foster cross-border collaboration. [9]

1.4. The Future of Metaverse

There has been rapid development of foundational technologies such as blockchain, artificial intelligence, virtual reality, and augmented reality, which have facilitated immersive virtual experiences. Researchers have focused on interdisciplinary approaches, drawing from sociology, psychology, and computer science to delve into various aspects of user experience in virtual environments. Despite progress, challenges persist in creating a seamless metaverse system that integrates high-quality content, devices, and interactions to impact the user experience positively. [10]

Tencent CEO Ma Huateng mentioned that the mobile Internet era has passed and the future is the era of the all-real Internet. Factoring that in, the Metaverse is this integration of entities and digital economies, and it is also predicted to keep a fully-fledged economy where digital assets, virtual content, and currencies circulate. Also, an investment surge is expected across the three sectors:

1. **Virtual goods market:** This market has been projected to grow from $50 billion to $190 billion by 2025.
2. **AR/VR development:** The market expenditure is expected to increase with a CAGR of 54% from 2020-24.
3. **Cloud Computing:** Demand increases are forecasted for data storage and processing to support the Metaverse.
4. **Content Platforms:** Builders can create immersive virtual worlds integrating social, entertainment, advertising, and e-commerce functionalities. Business value will also increase with expanded user value chains. [22]
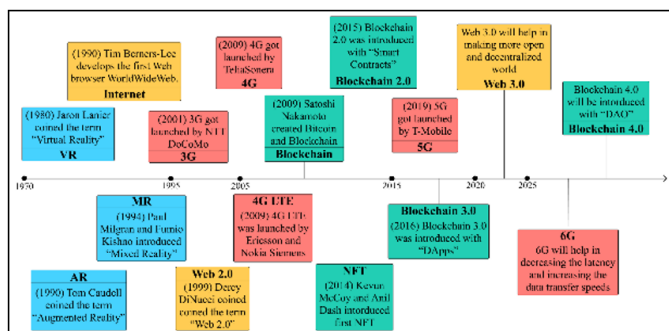

Figure 2: Timeline showing the emergence of technologies that have helped the Metaverse evolve. [11]

Chapter 2: Digital Twins

Digital Twins, a concept initially articulated by Michael Grieves during a 2002 conference at Michigan University, were further developed within the industrial sphere and associated with NASA in 2012. This concept aims to create virtual representations of physical entities, such as machinery or vehicles, by using sophisticated computer simulations and comprehensive datasets about their operation. This emulation enables enhanced safety and reliability by providing insights into performance, predicting maintenance needs, and optimizing operations.

Delving into this topic through more of a Metaverse perspective and understanding it better, it should be noted that the metaverse is evolving, and so are the terms and technologies associated with it. One such concept is "Digital Twins"; these digital simulations represent physical entities, such as objects, individuals, or locations, crafted through real-time data and advanced simulation models. Digital twins are digital replicas of real-world objects or systems, enhanced by real-time data.

In the context of the metaverse, they serve various purposes: [16]

• **Optimizing Manufacturing:** Companies are making virtual copies of their factories on computers. They do this to improve how things are made, find problems in the process, and make the production work better.
• **Creating Virtual Stores:** Companies are setting up online shops where customers can explore products in a lively digital space, with instant updates on product availability.
• **Transforming Business Meetings:** In the metaverse, virtual representations of people (Digital Twins) make customer meetings possible without being physically present. This offers detailed interactions, providing a thorough understanding of clients.

The Metaverse, however, always raises several concerns regarding privacy and security. As users continue to use the Metaverse, the collection of personal data will increase, and so will the threat. A significant threat is identity privacy: the theft of a user's identity can have extreme consequences, affecting their digital avatars, assets, and social interactions. The concept of digital twins can also be explored as a means of enhancing security. By creating digital representatives of one, these digital twins, when used with blockchain technology, can make the process relatively safer. [17]

FIG. 5. THE THREE-LAYER ARCHITECTURE OF CONNECTION BETWEEN PHYSICAL WORLD AND METAVERSE WITH THE APPROACH OF APPLYING DTs IN METAVERSE

Figure 3: The 3-layer Architecture of Connection Between the Physical World and the Metaverse with the Approach of Applying DTs in the Metaverse [13]

This architecture consists of three layers:
1. **Physical/Real World Layer:** Involves real-world users, components, and services connecting to the metaverse.
2. **Links (UI) Layer:** Connects the physical world to the metaverse, which includes sub-layers for simulation/migration and blockchain.
3. **Metaverse (Digital World) Layer:** Provides a 3D digital world where DTs are utilized, relying on blockchain and smart contracts.

The most attractive layer of the suggested architecture provides a 3D digital world (here, the Metaverse). The DTs used in this layer rely on blockchain and smart contracts. As with the physical world, all people, services, and things could be present in the Metaverse layer as DTs or NFTs, and they can enjoy the digital environment to resolve their problems. [13]

The integration of DTs and Metaverse, along with blockchain technology, has various benefits:
• Immutable and transparent DT transactions prevent cyber fraud.
• Decentralized management means there will be legitimacy.
• Blockchain enhances the security and reliability of metaverse-based DTs.
• Global traceability with blockchain, as it ensures high-accuracy tracking for DTs.
• Metaverse-based DTs streamline control and tracking of product lifecycles.
• DTs enable peer-to-peer communication, bypassing intermediaries.
• Blockchain technology helps to access privileges and trusted data coordination for DTs.
• Regulatory compliance for DTs.

Metaverse provides a decentralized infrastructure, meaning more reliability. The concept of the Metaverse represents the development direction of the next generation of the Internet,

and via Digital Twins, the two major technology systems complement each other and will lead the fourth industrial revolution. [14]

This evolutionary process relies on four key characteristics:
1. **Weak Distinction:** Some concepts are interdependent, such as virtual reality and Digital Twins, which mutually support each other.
2. **Sub-evolution:** New technologies emerge through the combination of old technologies and new demands. For instance, visualization has progressed from two to three dimensions and from aesthetic realism to intuitive visual analysis and prediction.
3. **Mutual Technical Assistance:** Different technologies support each other's evolution. For example, IoT drives virtual reality development, and artificial intelligence enhances virtual reality into Digital Twins.
4. **Pan-domain Application:** Virtual Reality and Digital Twins find extensive applications across various forms, scales, and fields. Virtual Reality can visualize phenomena from gaseous to solid states and from microscopic molecules to macroscopic solar systems.

However, some phenomena like flames and wind can only be simulated in the Metaverse, as they cannot evolve into Digital Twins. [14]

Chapter 3: Metaverse and Education
Zepeto is an augmented reality avatar service operated by Naver Z, and it is also a representative of the metaverse platform in Korea. It was launched in 2018, and it creates lifelike representations of users and explores virtual realities while engaging in social interactions. These classroom strategies and this evolving concept help facilitate interactive lessons, helping teachers transcend physical barriers and enter the digital realm. When users take their pictures, the application creates a 3D avatar that resembles the user. Moreover, the avatar is mutable because they can customize skin color, features, height, facial expression gestures, and fashion styles as they wish. [15]
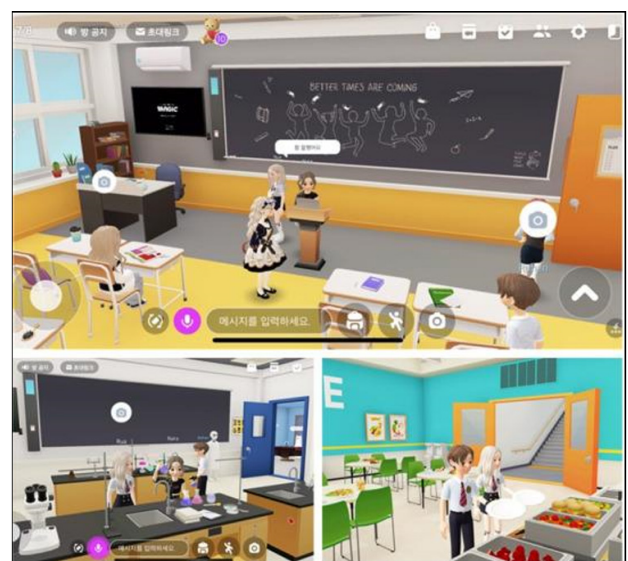
Figure 4: Class 2 map in Zepeto. [25]

Several applications of the Metaverse are expected to be beneficial to the technological world. One such application is using Metaverse in education. Metaverse will play a crucial role in Education 4.0 as well, where it will combine exponential technologies like cloud computing, robotics, artificial intelligence, and 3D printing. This integration marks a transition to the fourth industrial revolution in education.

This raises the question of how this concept can be taken forward. First, it is vital to understand the two major ways online learning has always worked: asynchronous and synchronous e-learning. Platforms like Moodle and Blackboard offer asynchronous learning, which means one can learn at their own pace and interact with course materials and instructors whenever one wants. Synchronous e-learning, on the other hand, happens in real time. It is like being in a virtual classroom where a student and their classmates can interact in real time. It is noteworthy that Metaverse can be significant in terms of online learning designed through it. [6]

Some of the advantages of "Metaverse in Education" include:
1. **Enhanced Learning:** Metaverse improves education as it offers interactive simulations like training and STEM education. AR and VR instructions help the students learn in a better and quicker way.
2. **Interactive Journalism:** Metaverse also includes immersive journalism with 360-degree photos and videos.
3. **Meta-Immersive-Education:** Meta-education goes beyond 2D platforms, as it engages the audience and the students with learning in such a way that helps them to grow better. Concepts like Spatial Computing and Brain-computer interfaces redefine computing control.

Additionally, the Metaverse is witnessing integration with blockchain and NFTs, unlocking a myriad of new possibilities [7]. However, everything has its pros and cons. While the metaverse has allowed students to socialize virtually during the pandemic, this has made students shyer during real-time meetups. Along with that, there is a lot of digital fatigue, impacting learning skills. Moreover, there will always be a fear of cyberbullying and privacy concerns.

The next question this raises is how teachers can move forward with this mode of teaching. Firstly, they should carefully analyze how students understand the Metaverse. They then must set up classes to solve problems or perform projects cooperatively, which will prepare them for the metaverse. Some applications of Metaverse in education which have already been implemented are:

1. **Virtual-Tee Anatomy Learning:** The Virtuali-Tee is an example of AR in education, allowing students to examine the inside of the human body as if it were an anatomy lab.
2. **Spinal Surgery Platform:** This is a spinal surgery platform developed in a hospital in Seoul that applies augmented reality technology. It uses a real-time projection of a pedicle screw onto a human body structure as an overlay graphic, demonstrating how AR can be utilized in medical education for training purposes and surgical simulations. [8]

Chapter 4: Advancements in the Metaverse

4.1 Initiatives by Countries
In today's rapidly evolving world, the concept of the Metaverse has fascinated the imagination of many nations. This digital realm has spurred a wave of initiatives across the globe; From small island nations like Tuvalu to technological powerhouses like South Korea, investing billions of dollars in Metaverse projects is a big achievement for the "buzzword" Metaverse. As we all enter the metaverse together, it's crucial to grasp the various efforts of countries and companies. This knowledge will guide us through this new era of digital innovation.

1. **Tuvalu**
   - Preserving its nation in the metaverse amid rising sea levels.
   - Digitally recreating land, ocean, and cultural assets to safeguard heritage.
   - Real-time tracking on the website uploads government buildings to local wildlife.
   - Learning from past extinction events, Tuvalu ensures the accessibility and resilience of its heritage, offering immersive educational experiences and setting a blueprint for other nations. [9]

2. **South Korea**
   - Leading in metaverse utilization for government services.
   - Investing 9.3 trillion won (about 51.6 billion yuan) in metaverse projects.
   - Established "Metaverse Seoul" for virtual citizen-government interactions.
   - Aim to transition all government services to the metaverse by 2026, enhancing accessibility and efficiency. [9]

3. **China**
   - Implemented a 5-year plan to leverage the metaverse for the public and private sectors.
   - Aiming to grow the local metaverse industry to $52 billion by 2025.
   - Introduced a $1.5 billion fund to support metaverse development.
   - Services like the "Metaverse Diagnose System" at Shanghai Eye Hospital enable remote patient treatment. [9]

4. **Saudi Arabia**
   - Celebrated its 92nd National Day in the metaverse in September 2022.
   - Showcased Saudi culture and history in Decentraland.
   - Event attendees explored traditions, arts, and history virtually. [9]

5. **United Kingdom**
   - Observed national mourning in the metaverse

following the death of Queen Elizabeth II.
- A tribute was paid at the Blockchain-British Association's (BBA) metaverse headquarters. [9]

6. Japan
- Formulated Metaverse Economic Zones (MEZs) for the development of an open metaverse ecosystem.
- Featuring "Auto-learning Avatars" and "Multi-Magic Passport" for interoperability.
- Development plans to construct a DAO for government bodies to enter Web3. [9]

7. Dubai, UAE
- Aspired to become the regional metaverse leader.
- Announced a 5-year metaverse strategy: has plans to establish 40,000 jobs in the virtual sphere and contribute US$ 4 billion to the economy by 2030, has launched metaverse accelerator, and has attracted blockchain venture funds.
- The Dubai government is about to host the Blockchain Summit as part of its movement to transition the landscape from a strictly regulated crypto-economy to one in the Metaverse. [9][19]

8. Vietnam
- A strong area of support for the metaverse, with more than half of tweets showing a positive sentiment.
- Propelled by the government to a more dynamic digital landscape and with the desire to achieve higher economic growth through the metaverse. [4]

9. Philippines:
- Welcoming the metaverse with arms wide open, realizing its potential to change the face of society and the economy.
- Government support for metaverse projects helps them rise and thereby has the country featured as a key place in the regional milieu. [4]

10. Indonesia:
- Positive concerning the Metaverse and appreciative of its latent metamorphic potential.
- The government actively encourages metaverse adoption and innovation to position the country as a regional hub. [4]

Metaverse interest in the USA
Along with these countries, there has also been some notable interest in the Metaverse in the United States. For example, Floridians have displayed collective interest as they have one of the highest rates of metaverse-related searches. Wyoming, too, has shown a lot of interest, with a significant percentage of positive metaverse-related tweets. Overall, a lot of the West Coast has shown positive influence, but the East Coast expresses more cautious sentiments. North Dakota remains an outlier, as it particularly expresses considerable negative sentiments.

Metaverse Size Comparisons
After comparing metaverse sizes to real-world locations, we get an actual idea of how big these digital realms are. For instance, NFT Worlds, the largest metaverse, covers an area equivalent to 60% of Brazil's territory. The Sandbox, a well-known metaverse, is approximately 20% the size of Florida's Disney World, while Decentraland encompasses about 40% of Central Park's iconic area.

Reviewing the world's engagement in the Metaverse, we still have to keep in mind some crucial things affecting the engagement: cultural, economic, and geographical factors influence the perspectives of countries and regions toward emerging technologies like the metaverse. [4]

4.2. Companies
A lot of companies have recently started adapting to the metaverse; companies like Meta (formerly Facebook), Microsoft, and Nvidia, along with startups, have embraced this concept [3]. NVIDIA's Omniverse Enterprise is a pivotal platform that collaboratively helps in digital creation. With their GPU, renowned for its role in gaming and entertainment, they provide top-tier graphs too. Advancements like the Nvidia Omniverse are giving rise to transformative applications of the idea. For example, BMW leveraged the Omniverse to help boost its factory operations by creating digital twins. This led to a remarkable 30% improvement in production planning efficiency. Similarly, Ericsson employed the Omniverse to construct city-scale digital twins, and along with that, using 5G antennas has shed even more light on this latent, but interesting topic.

Lowes, a major player in the home retail sector, has also used the Omniverse for digital twins and provided its employees with augmented reality headsets that enhance customer support. This immersive approach enhances the customer experience because it helps deliver real-time inventory and product information. At the end of the day, this helps Lowes understand its customers and their requests better. [2]

Some other companies have invested in the Metaverse:
1. Cerveza MUR:
- Cerveza MUR plans to enter the Metaverse to finance itself outside traditional channels and as a new form of entrepreneurship.

2. Qurable and Maria Cher:
- Qurable intends to enter the Metaverse but has partnered with Maria Cher for its immersion.

3. Heineken:
- Heineken has launched a virtual beer called 'Heineken Silver' inside its virtual brewery in Decentraland. The best part about this virtual drink is that instead of using nutritional values, it comes with virtual values such as pixels (0g), HTML (0g), RGB Colors (0g), Render (0g), glitch (0g), and others.

4. Skechers:
- The American footwear company Skechers has also joined the metaverse bandwagon. According

to NFCevening, Skechers has signed a lease in Decentraland's fashion district. Michael Greenberg, president of Skechers, said in a press release, "We look forward to embarking on this virtual era, and exploring creative ways for our brand to engage with new customers and audiences as we launch the new Skechers experience."

Figure 5: Sketchers store in the Metaverse [20]

4.3 Gaming Standpoint

The gaming industry has finally transformed after a long process. Due to advancements in computer vision, AR, VR, and 3D-rendering engines, the gaming industry now stands at a notable position. Modern games are decentralized and they are mostly peer-to-peer driven. Everything takes place in a gaming environment (GE) and all the data stored in the game is stored on game servers (GS). In VR GEs, players use assisted VR hardware like head-mounted displays and hand controllers, immersing themselves in virtual environments. On the other hand, AR GEs, such as Pokémon Go, overlay digital information onto the real environment. [18]

Gaming has been one of the most successful use cases of Metaverse and has had a large user base over the last two decades. Some other examples are Epic Games Fortnite and Roblox. Not only does Meta (formerly Facebook) offer gaming on this platform, but other giants like Microsoft, Apple, Amazon, Google, Alibaba, Tencent, and Byte Dance are also venturing into the Metaverse, with considerable growth being forecasted in a short period. [21]

A report by DappRadar suggested that the metaverse's penetration would reach USD 1.3 billion in the gaming industry in 2022 (third quarter). It is estimated that GM projects will drive NFT-based assets and tokens on Web 3.0 platforms, with 912,000 crypto wallets created every day globally.
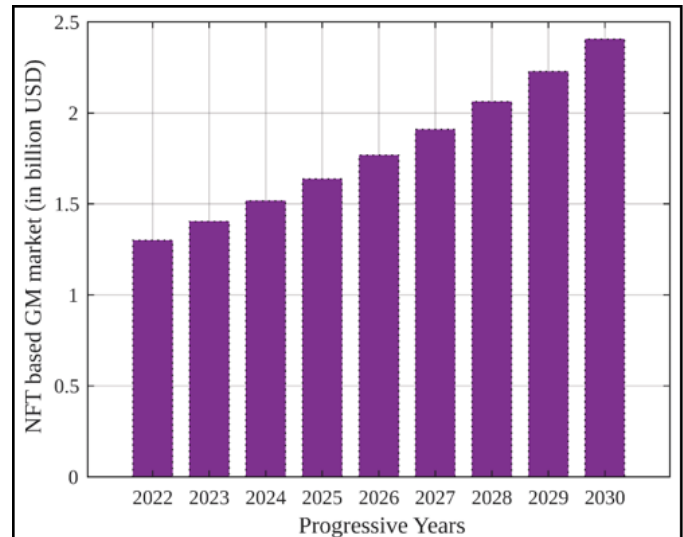

Figure 6: Global market cap of NFT-asset-based GMs by 2030, showing a CAGR of 8% [4].

The Metaverse, originally meant for gaming and social spaces, is now branching into various industries beyond entertainment. Research shows it has potential applications in tourism, real estate, medicine, and engineering. This expansion signifies a transformative shift, promising immersive experiences and innovative opportunities beyond traditional gaming realms. As the Metaverse continues to evolve, it's clear that its impact will extend far beyond gaming, shaping the future of multiple sectors and redefining how we engage with virtual environments. [21]

CONCLUSION

The Metaverse, as we now know, has immense potential. Companies and countries worldwide are now actively using the Metaverse. Investments from companies like Meta, Microsoft, and Nvidia are adding to its development, boosting the global economy. Advanced technologies such as AR, VR, and blockchain, aligned with the Metaverse, offer diverse applications across social interactions, education, and more. A concept first introduced in 1992, it is more than a buzzword now; it is a promising start to a revolutionary future.

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